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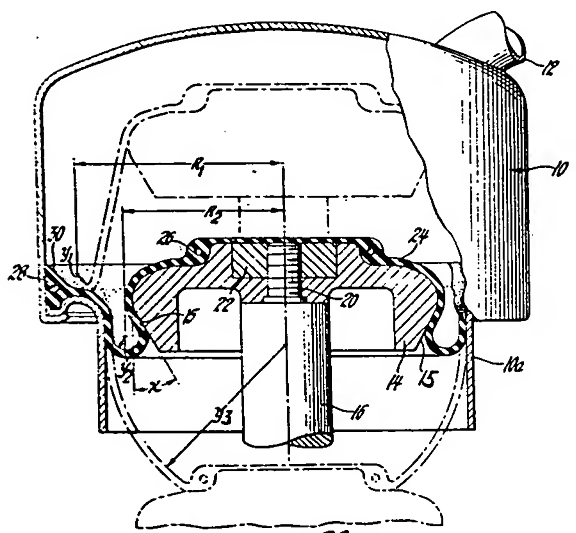

Fig. 1

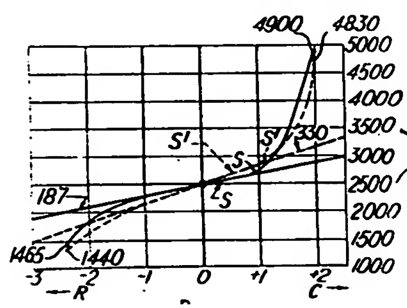

Fig. 3

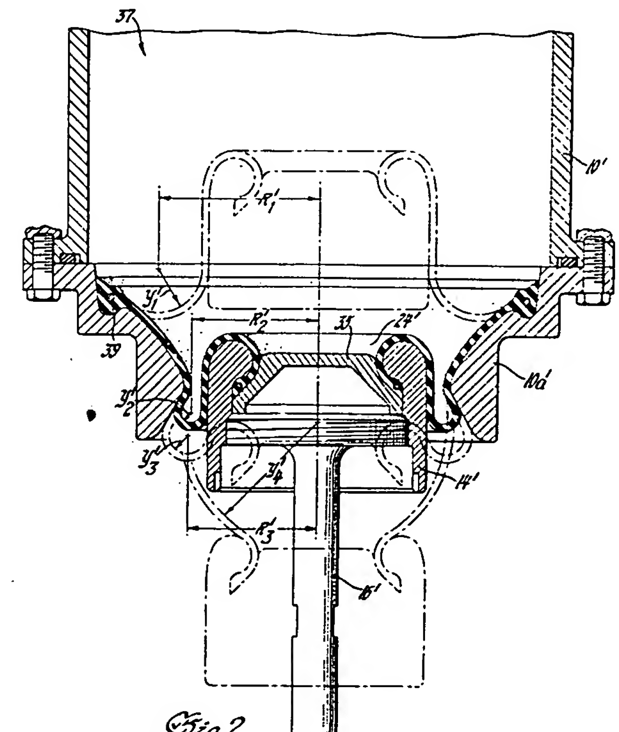

Fig. 2

Interface with Seal (o-rings)

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COMMONWEALTH OF AUSTRALIA.

36, 207/58.

PATENT SPECIFICATION

Complete Specification Lodged .... 19th March, 1958.

Application Lodged(No.36, 207/58) .... 19th March, 1958.

Applicant .... General Motors Corporation.

Actual Inventor .... Von Dale Polhemus.

Convention Application.
(United States of America, 8th April, 1957).

AUSTRALIA DIV.

LAPSED BEFORE ACCEPTANCE.

Complete Specification Published .... 18th September, 1958.

Classification 96.5.

Drawing attached.

COMPLETE SPECIFICATION.

"IMPROVED PNEUMATIC SPRING".

The following statement is a full description of this invention including the best method of performing it known to us.

This invention relates to pneumatic springs and more particularly, though not exclusively, air springs for use in motor vehicle suspensions.

Such a pneumatic spring comprises a gas retainer, adapted to be supplied with gas under pressure, a piston reciprocable within the retainer and a flexible diaphragm which interconnects the piston and retainer, and has an annular loop between an external wall of the piston and an internal wall of the retainer.

By the invention it is possible to reduce the spring rate in the normal position without increasing the volume of the retainer. Accordingly one of the walls is of tapered frusto-conical form, whereby the space between the walls increases outwardly of the retainer.

The angle of taper of the one wall may be between 7.5° and 30°, but is preferably between 10° and 20°.

The scope of the invention is defined by the appended

claims; and how it can be carried into effect is hereinafter particularly described with reference to the accompanying drawings, wherein:-

Figure 1 is a section through one form of pneumatic spring according to the invention;

Figure 2 is a section through another form of pneumatic spring; and

Figure 3 is a graph illustrating the characteristics of the spring shown in Figure 1.

The air spring includes an air retainer tank 10, into which air is introduced or from which air is exhausted through a conduit 12 which leads to a levelling valve (not shown). The retainer tank 10 is secured to the body or frame of a vehicle and has an inturned flange round its open lower end. To this flange is secured an out-turned flange on an annular curved top portion of a short depending cylindrical wall 10a which forms a lower portion of the tank 10.

Confined within the retainer tank 10 and the lower portion is a piston 14 having a shaft 16 connected to a wheel-carrying member, for example an axle (not shown). The shaft 16 at its upper end has a threaded portion 20 passing through the body of the piston and secured by a nut 22 disposed in a recess formed in the piston.

The piston 14 is connected to the tank or reservoir 10 by a flexible diaphragm 24 of elastomeric material, such as rubber, reinforced with nylon or rayon cords. The diaphragm 24 includes an inner bead ring 26 and an outer bead ring 28, both of interwoven wire strands. The rings 26 and 28 may, however, be solid metal or plastic rings. The diaphragm 24 is disc-like and the ring 26 is seated in a groove in the piston 14. The diaphragm is maintained in engagement with the piston 14 by pressure of air in the reservoir.

The bead ring 28 is seated on the annular flanges of the tank 10 and lower portion 10a and has a flexible tapered lip 30 which is pressed into sealing engagement with the tank 10 by the air pressure in the retainer tank or reservoir.

The diaphragm 24 depends in an annular loop between the wall of the piston 14 and the wall of the lower portion 10a of the tank. As the piston moves up and down in the tank, the diaphragm is peeled off the wall on one side of the loop and on to the opposite wall.

Instead of being parallel to the wall 10a, the wall of piston 14 is rounded and has a lower tapered portion 15 of frusto-conical shape, the angle $\underline{x}$ of taper being between 7.5° and 30°, and preferably between 10° and 20°. The effect of the taper which is downward and inward is that, as the piston moves up into the tank on compression, the diaphragm is peeled

off the cylindrical wall 10a and on to the wall 15. The contact line of the diaphragm with the piston from which the loop starts moves down the wall 15, decreasing in radius. Thus the radius of the section of the loop (y_2 in the normal position, Figure 1) increases. As the wall 10a is cylindrical the centre of the section of the loop moves inwardly.

The load on the piston in any position is the air pressure times the effective area, which is $\pi \cdot R^2$ where R is the distance from the axis of the piston to the centre of the section of the loop of the diaphragm.

Accordingly, as the centre of the section of the loop moves inwardly during the initial portion of a compression stroke, the effective area of the piston decreases. Conversely, during the initial portion of a rebound stroke, the effective area of the piston increases.

The effect of this on the suspension is illustrated in Figure 3, which is a graph of load L in pounds against displacement D in inches on compression and rebound. The spring rate, which is a measure of the stiffness of the spring, is defined as the load increase per inch of deflection and is indicated by the slope of the curve at any point.

The full-line curve S is that obtained with a spring as shown in Figure 1, and the dotted-line curve S' is that obtained with a similar spring, having a parallel-walled piston and retainer skirt. With the vehicle at rest, that is, in a condition of zero deflection, the load on each spring is 2,500 lbs, the effective area being 25 sqare inches and the air pressure 100 pounds per square inch. Each spring has a volume of 291 cubic inches. The spring rate for the curve S during initial movement in compression or rebound is 187 pounds per inch as indicated by the line 187 and for the curve S' is 330 pounds per inch as indicated by the dotted line 330.

Thus with any load within the range 1,850 to 3,100 pounds, there is more deflection of the spring of the curve S than of the spring of curve S'. This means that the spring of curve S' is relatively stiff in the indicated load range which is the most usual ride range. Accordingly an air spring with a parallel-walled piston and retainer skirt, in order to have a similar soft ride to a spring having a tapered wall, must have a substantially greater volume. The somewhat greater stiffness of the spring of curve S above 3,100 pounds load is hardly appreciable as a practical matter and represents but little sacrifice for the softer ride experienced within the critical load range.

This lowering of the spring rate is obtained because the effective area of the piston during the initial portion of the compression stroke decreases rather than increases. It is not until a deflection of

one inch, represented by +1, is approached that the effective area of the piston begins to increase as shown by the upturned portion of the curve. Downward displacement of the piston, on the other hand, is marked initially by an increase in the effective area of the piston, which maintains of relatively low-spring rate until a deflection of one inch, represented by -1, is reached, when there is a relatively abrupt decrease.

In the full bump position with the spring compressed to a maximum, the effective area of the piston is $\pi \cdot R_1^2$, where R_1 is the distance from the axis of the piston to the centre of the section of the loop of the diaphragm whose radius is y_1. In the normal ride position, the effective area is $\pi \cdot R_2^2$ and the radius of the loop is y_2. In the full rebound position, the centre of the section of the loop lies on the axis of the piston, the radius of the loop being y_3, so that there is no effective area of the piston. An advantage of this is that there is no need of a rebound stop.

In the modified spring shown in Figure 2, there is a retainer tank 10', a piston 14', a piston rod 16' and a diaphragm 24'. The internal wall of a lower portion 10a' of the retainer tank 10' is tapered whilst the wall of the piston 14' is cylindrical. Such tapering is downward and outward and the construction being the converse of the construction of Figure 1, gives similar effects. The piston 14' is internally threaded to accommodate the head of the piston rod 16', which head bears against a clamp piece 35 which grips the diaphragm 24' to the upper portion of the piston. The pressure of the air within the chamber 37 formed by the tank 10' is relied upon to maintain the seal at an outer bead 39 of the diaphragm 24'.

In compression, the effective radius of the piston is R_1^1 and the loop radius is y_1^1. In the normal position, the effective piston radius is R_2^1 and the loop radius is y_2^1. Upon initial rebound movement, the diaphragm is peeled off the piston and onto the outward tapered wall 10a'. Accordingly the loop radius y_3^1 is greater than before and the centre of the loop moves away from the cylindrical piston wall. Thus the effective piston radius R_3^1 is greater than R_2^1. Upon full bump, the diaphragm loop radius is y_4^1 and the loop centre lies on the piston axis so that there is no effective piston radius.

The claims defining the invention are as follows:-

1. A pneumatic spring comprising a gas retainer, adapted to be supplied with gas under pressure, a piston reciprocable within the retainer and a flexible diaphragm which interconnects the piston and retainer and has an annular loop between an external wall of the piston and an internal wall of the retainer, one of the walls being of tapered

frusto-conical form, whereby the space between the walls increases outwardly of the retainer. (8th April, 1957).

2. A spring according to claim 1, wherein the angle of taper of the one wall is between 7.5° and 30°. (8th April, 1957).

3. A spring according to claim 2, wherein the angle of taper of the one wall is between 10° and 20°. (8th April, 1957).

4. A spring according to claim 1, 2 or 3, wherein the one wall is the internal wall of the retainer. (8th April, 1957).

5. A spring according to claim 1, 2 or 3, wherein the one wall is the external wall of the piston. (8th April, 1957).

6. A pneumatic spring comprising a gas retainer, which is adapted to be supplied with gas under pressure and which includes an upper reservoir portion and a lower reservoir portion of reduced diameter, the upper end of the lower reservoir portion being rounded, a bulbous piston reciprocable within the retainer and having a lower wall portion of frusto-conical formation tapering inwardly at an angle between 10° and 20°, a shaft extending from the piston and coaxial therewith, and a flexible diaphragm overlying the head of the piston and the rounded end of the lower reservoir portion, the flexible diaphragm having an outer bead incorporating a tapered lip sealingly engaged with the inner wall of the upper reservoir portion of the retainer, the flexible diaphragm having an annular loop between the wall of the piston and the inner wall of the lower reservoir portion of the retainer. (8th April, 1957).

7. A spring according to claim 6, wherein the shaft is threaded and is secured to the piston by a nut accommodated in a recess formed in the head of the piston. (8th April, 1957).

8. A pneumatic spring comprising a gas retainer, which is adapted to be supplied with gas under pressure and which includes an upper reservoir portion and a lower reservoir portion having an inwardly bulging inner wall the lower surface of which is of frusto-conical formation to taper at an angle of between 10° and 20°, a cylindrical-walled hollow piston reciprocable within the retainer, a flexible

diaphragm having an outer head sealingly engaged with the inner wall of the retainer and an annular loop between the walls of the piston and retainer, and a shaft extending from the piston and having a flanged upper end bearing on a clamp between which and the piston the diaphragm is secured. (8th April, 1957).

9. A spring according to claim 8, wherein the flanged upper end of the shaft is threaded into the piston. (8th April, 1957).

10. A pneumatic spring substantially as hereinbefore particularly described and as shown in Figure 1 of the accompanying drawings. (8th April, 1957).

11. A pneumatic spring substantially as hereinbefore particularly described and as shown in Figure 2 of the accompanying drawings. (8th April, 1957).

PHILLIPS, ORMONDE, LE PLASTRIER & KELSON.
Patent Attorneys for Applicant.

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Serial No.	Application No.	Classification.
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218,028	34,969/58	96.5
212,502	26,579/57	96.5.

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